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EXPERIMENTAL INVESTIGATION ON THE AL 7075/ ZIRCONIUM OXIDE & GRAPHITE COMPOSITE MATERIAL FOR MODERATE TEMPERATURE APPLICATIONS

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ABSTRACT

Conventionally, two different liquids are used in automobile industries for lubrication and cooling purpose, and its property variations demand different handling systems (pump, storage tank, etc.). In this project, we propose to use single fluid for both lubrication and cooling purpose, which reduces the number of accessories and also promotes interchangeability. Magnetorheological fluid (MRF) is highly viscous in nature; generally viscous fluids are good in lubrication, but fail to provide required cooling effect because of its high kinematic viscosity, whereas, with the small influence of magnetic field intensity, magnetorheological fluid could act as a heat transfer fluid.

KEYWORDS: Zirconium Oxide & Composite Material

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Original Article

INTRODUCTION

Magnetorheological (MR)fluids, which are stable disperse systems composed of two phases, such as magnetic particles (of size 3-10µm) and hydrocarbon (or water, oil, bio-compatible liquid), are mainly used to manufacture the controllable dampers, actuators and brakes [1]. The magnetorheological (MR) material is a kind of controllable or magnetic field responsive smart material. In general, it is in the form of fluid of dispersion of non-colloidal and polarizable particles in a viscous non-magnetic carrier [2]. The main characteristic of these fluids is their ability to change reversibly from free-flowing, linear viscous liquids, to semi-solids with the yield strength swiftly and continuously controllable (milliseconds scale dynamics) when exposed to magnetic field. In the absence of an applied field, the MR fluids exhibit Newtonian-like behavior [3,12]. Magnetic fluid, also called Ferro fluid, is a new-style magnetic material which property and morphology are varied with external magnetic field. It mainly consists of carrier fluid and suspended magnetic particles with a size of about 10 nm in diameter. Magnetic fluid behaves as the flow ability like the Newtonian carrier fluids [4]. The different types of magnetic particles, such as carbonyl iron (CI), iron oxide (magnetite and maghemite and alloys, CI particles, owing to their high saturation magnetic property, are used mainly for fabricating MR fluids [5]. Fluids with controllable rheology and thus the damping properties, such as electrorheological (ER) and magnetorheological (MR) fluids, have been used in various semi-active vibration control applications. Such fluids exhibit rapid change in their rheological, damping and stiffness properties with application of an electric or magnetic field, respectively. However, the ER

fluids exhibit a number of shortcomings compared to the MR fluids including low yield strength, requirement of high voltage and greater sensitivity to common impurities [6]. The properties of the magnetorheological fluid (MRF-DG 132) are: its base fluid is hydrocarbon. The operating temperature of the fluid is -40 to 130ºC. The density of the fluid is 3090 kg/m^3. The color of the fluid is dark grey. The yield stress of the fluid is 45 kPa, the weight percent solid of the fluid is 81.64%, the specific heat at 25ºC is 800J/kg K, thermal conductivity at 25ºC is 0.25-1.06 W/m K. The flash point is greater than 150ºC [7,15]. A typical MR fluid contains 20-40% by volume of relative pure, soft iron particles are suspended in mineral oil, synthetic oil, water or glycol [8]. Rheological properties of MR fluids under various working conditions are important in MRF systems. It illustrated that rheological properties of MR fluids vary in the presence of a magnetic field due to cross-linked columnar structures of ferromagnetic particles. The rheological properties are further dependent on the size and volume fraction of abrasive and ferromagnetic particles suspended in the base fluid; an increase in the size of particles leads to yield stress increment of the medium due to better putting the larger particles into the chain structure [9,13,14]. The transformation of rheological properties is controllable and reversible that magnetorheological fluids have broad application prospects in aviation, aerospace, automotive industry, hydraulic transmission, biotechnology, medical care and other field. The rheological properties depend on its microstructure, thus to understand the mechanism of MRF, we need to strengthen research the form and evolution of microstructure. Currently, there are a lot about the numerical simulation method and theory of the MRF microstructure [10]. The advantages of use this kind of fluids in machining process are related to their properties: they can work at a wide range of frequencies, they have reduced response time, they can be interchangeable easily and they can return to their natural liquid state (reversible) [11].

MATERIALS AND METHODS

Table 1: Properties of Magnetorheological Fluid

Parameters	Values
Appearance	Dark Gray Liquid
Density (g/ml)	2.90
Viscosity @ 0º Pa.s	0.92
Max .Yield Stress @ 140 KA/m	69 KPa
Operating Temp. Range ºC (ºF)	-20 to 150 (-4 to 302)
Flash Points ºC (ºF)	>180 (>356)
Power Requirements	2–24V @ 0.5-2A
Response Time	<Milliseconds

The magnetorheological fluid specimen is shown in the figure 1. The physical state of the magnetorheological fluid is liquid I state. It's insoluble in H_2O. The volatile by weight of the fluid is 0.22%. The volatile by volume of the fluid is 0.68%. Vapor density and Evaporation rate for this fluid is not applicable. Odor threshold, Freeze point and Vapor pressure for this fluid are not determined. Carbon Dioxide, Dry chemical, Foam, Water Fog are the extinguishing medium of this fluid. It's stable under normal storage conditions.

Figure 1: AMT-SMARTEC MR Fluid

Figure 2: AVL Engine Test Specimen

Table 2: Engine Specification and Performance Parameters

Parameters	Value
Ambient temperature (ºC)	27
Calorific value of fuel (kJ / kg)	42,000
Fuel density (kg /m^3)	830
Fuel pipe diameter (mm)	12.40
Orifice diameter (mm)	20.00
Fuel type	Diesel
Orifice co-efficient of discharge	0.60
Pulses per revolution	360
Dynamometer arm length(mm)	185
Rev. speed	8000 rpm
Bore	65-100 mm
Torque	180 Nm
Stroke	60-90 mm
Power	60 Kwa
Displacement	0.2-0.75 L
Peak pressure	20 Mpa

The test engine specification is listed in the above table 2. An AVL ENGINE is chosen for the testing purpose. The engine setup is shown in the figure 2. The specific gas constant of the engine is 1.00 kJ/kg K. The air density and the Adiabatic index are 1.17 kg/m^3 and 1.41. The combustion parameters of the polytrophic index are 1.26. There are 10 number of cycles in the engine. The TDC reference of the combustion of the engine is 0.

RESULTS AND DISCUSSIONS

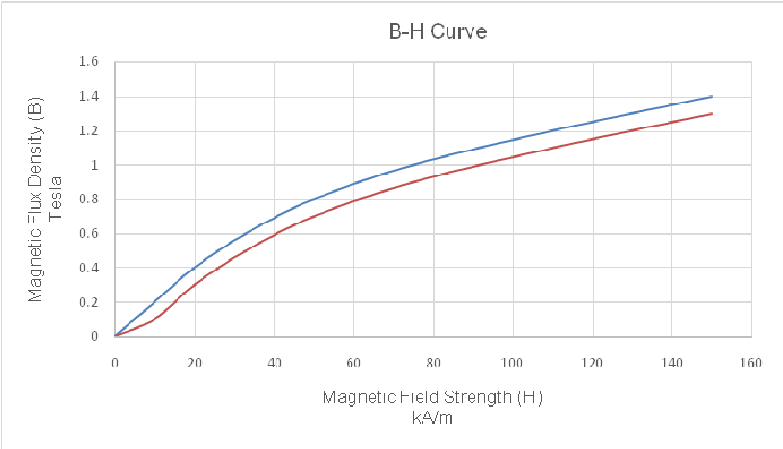

Figure 3: B-H Curve of MRF Fluid

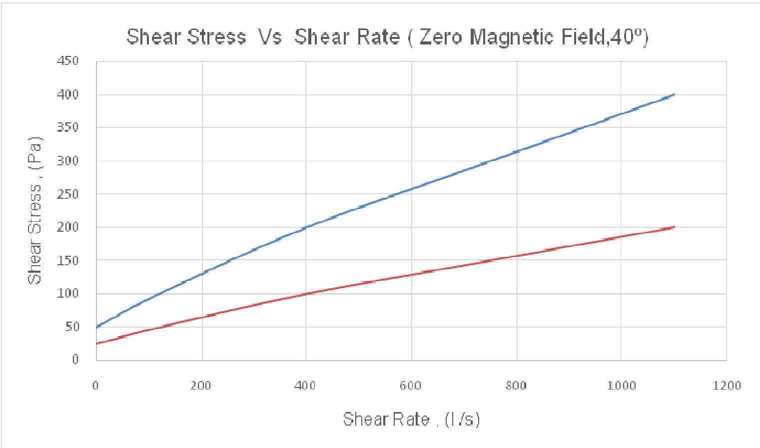

Figure 4: Shear Stress Vs Shear Rate

The preliminary test was conducted to understand the behavior of diluted MRF fluid. In the figure 3, the property variations of diluted fluid are compared against the concentrated fluid. The experiment was carried out under atmospheric condition and the result shows that the magnetic flux density decreases with dilution, whereas even after dilution magnetic flux density is constantly increase with increasing in the magnetic field strength.

The preliminary test led to comprehend the conduct of weakened MRF liquid. In the figure 4,the property variety of the weakened liquid is looked at against the concentrated liquid. The investigation was completed under zero magnetic field at 40º and the outcomes demonstrates that the shear pressure is diminishes with weakening, in the meantime after the weakening the shear pressure is steadily increment with expanding in the shear rate.

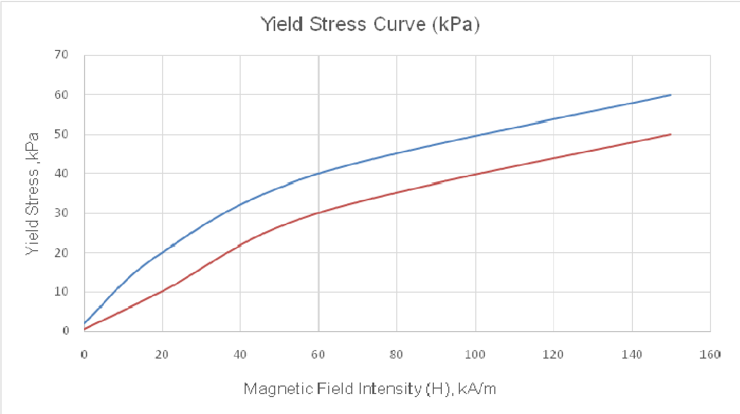

Figure 5: Yield Stress Curve

The trial test was led to comprehend the yield pressure bend of the weakened MRF liquid. In the figure 5, the property variety of the weakened liquid is analyzed against the concentrated liquid. The analysis was completed and the outcome demonstrates that the yield pressure is diminishes with weakening, while after the weakening the yield pressure is always increment with expanding in the magnetic field intensity.

The test was directed to comprehend the nusselt number against the inlet velocity for constant wall temperature for fully developed flow with different parameters; in the figure 6, the property variety of the water and ethylene glycol blend is most astounding among alternate parameters due to its specific heat and viscosity. Then, the MRF parameter is most reduced among alternate parameters because of its lower density in their property.

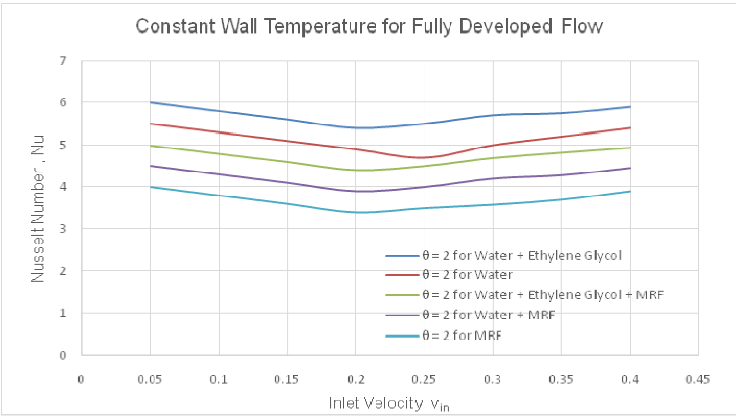

Figure 6: Constant Heat Temperature for Fully Developed Flow

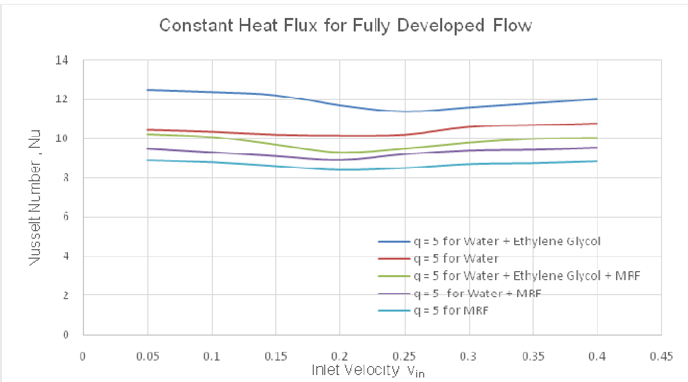

Figure 7: Constant Heat Flux for Fully Developed Flow

The preliminary test was directed to comprehend the nusselt number against the inlet velocity with different parameters in the constant heat flux for fully developed flow. In the figure 7, the property variety of the constant heat flux for fully developed flow of the considerable number of parameters have a diminishing with expanding in the inlet velocity against the nusselt numbers.

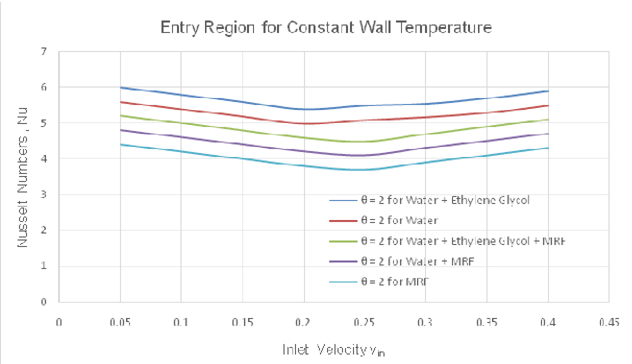

Figure 8: Entry Region for Constant Wall Temperature

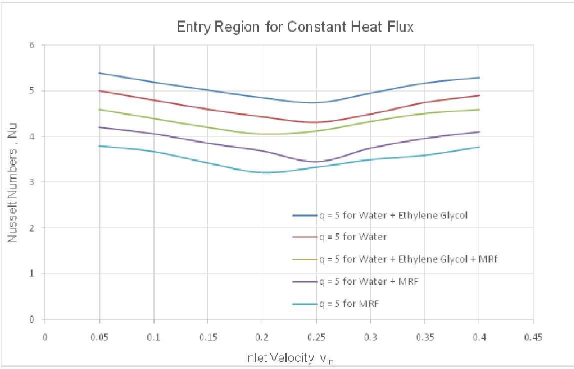

Figure 9: Entry Region for Constant Heat Flux

The test was led to comprehend the nusselt number against the inlet velocity with different parameters in the entry region for constant wall temperature. In the figure 8, the property variety of the constant wall temperature for entry region section district of all parameters in the nusselt numbers are diminish with expanding in the inlet velocity.

The fundamental test was led to comprehend the nusselt number against the inlet velocity in the entry region for constant heat flux with different parameters. In the figure 9, the property variety of the nusselt number is diminishing with expanding in the inlet velocity.

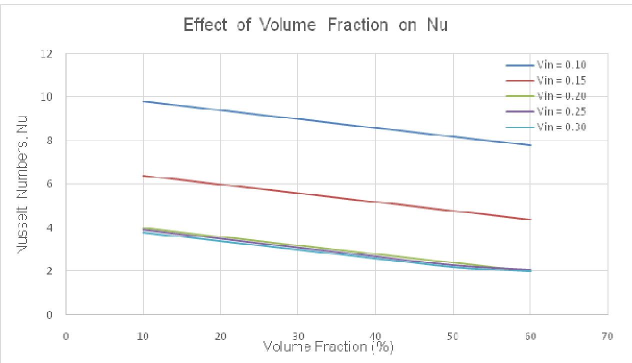

Figure 10: Effect of Volume Fraction on Nu

The test was directed to comprehend the nusselt number against the volume fraction in the effect of volume fraction in nusselt number with different derived parameters. In the figure 10, the property variety of the nusselt number is always diminishing with diminishing in the volume fraction.

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